REMARKS:

Claim 6 has been amended. New claims 23-25 have been added. A check in the amount of $75 is attached to satisfy the fees for three additional dependent claims. Claims 1-25 are active in the application.

Claims 23, 24, and 25 are supported by Figs. 2, 5, and 8, which show that there is no diode in the present buck converter.

The Office Action confused the identification of the synchronous switch with the auxiliary switch. The synchronous switch Q3 is defined as connected in parallel with the resonant capacitor Cr. The auxiliary switch is defined as connected between the connection point and the return potential. The auxiliary switch is connected in series with the top switch Q1. In Chida, the switch S of Fig. 1 is akin to the present synchronous switch Q3 in that it is connected in parallel with a resonant capacitor Cr.

Claims 1, 5-7, 15, and 19-22 were rejected under 35 USC 103(a) as being unpatentable over US patent 5,067,066 to Chida in combination with admitted prior art Fig. 1 and US Patent 5,663,635 to Vinciarelli et al. While not stated in the office action, it is believed that this rejection also applies to claims 2-4 and 16-18. Claims 8-14 were rejected under 35 USC 103(a) as being unpatentable over Chida in combination with admitted prior art Fig. 1, Vinciarelli et al. and US patent 6,429,628 to Nakagawa. These rejections are traversed.

The present invention provides a quasi-resonant buck converter having a resonant capacitor Cr, resonant inductor Lr and synchronous switch Q3. The resonant capacitor, resonant inductor and synchronous switch are designed and operated so that they apply a reverse current through the body diodes of the buck switches (top and auxiliary switches Q1 Q2) at turn-on so that zero voltage switching (ZVS) is provided. Also, they oppose current flow through the buck switches at turn-off so that zero current switching (ZCS) is provided. These aspects of the present invention can be appreciated from examination of Fig. 3, 6 and 9. Current through the resonant inductor Lr, for example, is zero or close to zero at Q2 turn off T4. Consequently, the present invention reduces body diode conduction loss and reverse recovery loss.

The Office Action argues that it would be obvious to incorporate top and auxiliary switches (i.e. switches Q1 Q2) from a buck converter circuit (akin to the admitted prior art Fig. 1 or Vinciarelli et al. Fig. 7) into the converter of Chida Fig. 1. This argument is erroneous for several reasons:

1) Vinciarelli et al. do not teach a buck converter in Fig. 7. Buck converters require two switches (Q1 Q2 or S1 S2) connected in series between the power source and return potential. Vinciarelli et al. Fig. 7 shows a converter with a single switch 25. Vinciarelli et al. does not teach top and auxiliary switches (S1 and S2 in present Fig. 1), which are required in a buck converter. Therefore, the combination of Vinciarelli et al. and Chida will not produce the present invention as claimed in claims 1 or 15, since these claims require both a top switch Q1 and auxiliary switch Q2.

2) Chida necessarily employs a constant voltage power source Vin. The combination proposed in the Office Action would require replacing the constant voltage power source Vin with a pulsed power source having top and auxiliary switches. However, there is no motivation or reasonable expectation of success in making such a radical change to the circuit of Chida. Replacing the constant voltage source Vin of Chida with two switches is not obvious or suggested by the admitted prior art, Chida, or Vinciarelli et al. It is noted that neither Chida nor Viancarelli et al. teach or suggest the use of two switches (top and auxiliary switches). Also, providing a pulsed power source in Chida would require the removal of the input capacitor Cin

3) Also, there is no motivation to combine Vianciarelli et al. Fig. 7 with Chida because these circuits operate very differently. Specifically, Chida Fig. 1 employs freewheeling current when switch S is off. By comparison, when switch 25 of Vianciarelli et al. is off, no freewheeling current through Lr1 is possible. This difference is important to the operation of both circuits, and hence, there is no motivation to combine the circuits or a reasonable expectation of success in combining the circuits.

4) Also, Chida necessarily has a diode D1 in series with the resonant inductor Lr. The diode D1 in Chida prevents reverse current flow and voltage dips across the load. Without the diode D1 in Chida, the voltage across the load will not be well regulated. Hence, the Diode D1 is essential in Chida and cannot be removed in the proposed

combination. The present invention does not include a diode. This aspect of the present invention is expressed in dependent claims 23, 24, and 25.

5) Additionally, the proposed combination will not produce the circuit as claimed in claims 1 or 15. Claims 1 and 15 both require that the resonant inductor is connected to the connection point, and that the resonant capacitor and resonant inductor are connected in series. These limitations, taken together, necessarily require that the resonant inductor is connected 'upstream' from the resonant capacitor. By comparison, the resonant inductor Lr of Chida is connected <u>downstream</u> from the resonant capacitor. Consequently, the circuit of Chida must be rearranged (exchanging the positions of inductors Li ad Lr), in order to produce the present invention as claimed in claims 1 and 15. Hence, simply adding top and auxiliary switches Q1 Q2 to Chida will not produce the present invention as claimed. Additionally, the circuit of Chida will be inoperable if the positions of inductors Li and Lr are exchanged.

It is important to note that the input inductor Li of Chida should be as large as possible to provide a constant current source and suppress current dips or surges. By comparison, the resonant inductor Lr is comparatively much smaller so that it is tuned to resonate with the resonant capacitor Cr (see Figs. 4A-4C).

The presence of the constant voltage source Vin in Chida reveals why the resonant inductor Lr must be located downstream from the resonant capacitor Cr. In Chida, the "input inductor (Li)....stores current energy from the DC power source (Vin) during on-time of switching circuit..." (col. 1, lines 52-54, see also col. 2, lines 51-53). Hence, the input inductor must be located upstream from the resonant capacitor Cr and resonant inductor Lr. With the input inductor Li necessarily located upstream from the resonant capacitor Cr, the resonant inductor Lr cannot be located upstream, which is required in the present invention. In other words, the constant voltage source Vin required by Chida is incompatible with locating the resonant inductor Lr upstream from the resonant capacitor Cr. Locating the resonant inductor Lr of Chida upstream of the capacitor Cr will render the circuit of Chida inoperable. Accordingly, any possible combination of Chida cannot have the resonant inductor located upstream from the resonant capacitor Cr, as required by present claims 1 and 15.

Also, regarding claim 15, neither Chida, present Fig. 1 nor Vinciarelli et al., nor admitted prior art Fig. 1 teach or suggest a transformer with a primary winding connected between the resonant inductor and the return potential. Hence, no conceivable combination of these references can produce the circuit claimed in claim 15. For this additional reason, the rejection of claim 15 must be withdrawn.

It is noted that the arguments 1-5 above relating to combination of Chida, Vianciarelli et al. and the admitted prior art also apply to the rejections of claims 8-14. US patent 6,429,628 to Nakagawa does not make up for the deficiencies of the combination, thus, claims 8-14 are not obvious over a combination of Chida, the admitted prior art, Vianciarelli, and Nakagawa.

Specifically regarding the rejections of claim 8-14, the Office Action alleges that it would be obvious to modify Chida to employ the coupled inductors 106 and clamping capacitor 105 of Nakagawa, since claim 8 requires coupled inductors and a clamping capacitor. These rejections are traversed.

Chida teaches that the resonant inductor Lr is located downstream from the resonant capacitor Cr. As noted above, Chida cannot be altered so that the resonant inductor is located upstream from the resonant capacitor, as required by claim 8 (this requirement necessarily follows from the combination of limitations (e) and (g)). Accordingly, the combination proposed in the Office Action will not produce the circuit claimed in claim 8. Hence, the rejection of claim 8 should be withdrawn.

Also, Nakagawa completely lacks a resonant inductor or resonant capacitor. Therefore, there is no motivation or reasonable expectation of success in combining Nakagawa with Chida or Vinciarelli et al. The Nakagawa circuit is not resonant. One of ordinary skill in the art would not be motivated to combine circuit elements from a nonresonant circuit (Nakagawa) into a circuit relying on resonance (Chida and Vinciarelli et al.). Accordingly, the combination is improper, and the rejection based on the combination should be withdrawn for this additional reason.

Also, the proposed combination of Chida, Vinciarelli et al., the admitted prior art and Nakagawa is quite complicated and strains the imagination. The Chida circuit must be combined with the resonant components Lr Cr of Vianciarelli, and the coupled inductors 106 and clamping capacitor 105 of Nakagawa. This combination relies on

picking and choosing individual circuit elements and combining them in the particular manner taught in the present application. There is no motivation in any of the cited references to alter and combine the circuits as proposed. For example, the Office Action does not explain why it would be obvious to incorporate Nakagawa's capacitor 105 and coupled inductor 106 into the circuit of Chida, other than to say "for the purpose of decreasing losses of the power supply". None of the references (including Nakagawa) teach that a coupled inductor and clamping capacitor 105 can provide such benefits to any given circuit, or any type of buck converter. Nakagawa teaches these benefits apply to the disclosed circuits only, and does not suggest employing coupled inductors 106 and clamping capacitors 105 into other types of circuits. Accordingly, there is no motivation to produce the proposed combination, and the rejection of claim 8 is therefore erroneous.

No explanation was provided for the rejections of claims 5, 6, 7, 19, 20, 21, or 22.

Regarding claim 5, none of the cited references teaches or suggests phase shift control of the synchronous switch to control output power. In fact, in Chida, phase shift control is not even possible since the circuit contains only one switch.

Regarding claim 6, none of the cited references teach or suggest operating the synchronous switch so that the on time is equal to the off time. Chida teaches that the off time should be set so that ZVS is provided, while the on time is set so that the output voltage is a desired value (see col. 2, lines 61-65). There is no reason to expect the on and off times will be equal when adjusted accordingly. Vinciarelli et al. is silent with respect to the relative on and off times of switch 44 in Fig. 7.

Regarding claim 7, none of the cited references teach that an off time of the synchronous switch is equal to $\frac{3}{2}\pi\sqrt{LC}$.

Regarding claims 12 and 19, none of the cited references teach or suggest controlling time period A (the overlapping ON times of the top switch Q1 and synchronous switch Q3) so that output power is controlled.

Regarding claims 13 and 20, none of the cited references teach or suggest controlling the combined durations of time periods A and B (ON time of top switch Q1) so that output voltage is controlled.

Regarding claims 11 and 14, none of the cited references teach or suggest that the quantity $\frac{3}{2}\pi\sqrt{(L+Lk)C}$ is controlled or selected to be any particular value.

Regarding claims 18 and 21, none of the cited references teach or suggest that the quantity $\frac{3}{2}\pi\frac{N_s}{N_p}\sqrt{(L+L_k)C}$ is controlled or selected to be any particular value. Also, none of the cited references teach or suggest that the off time of the synchronous switch can be proportional to a transformer turns ratio (Ns/Np).

In view of the foregoing, it is respectfully requested that the application be reconsidered, that claims 1-25 be allowed, and that the application be passed to issue.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

A provisional petition is hereby made for any extension of time necessary for the continued pendency during the life of this application. Please charge any fees for such provisional petition and any deficiencies in fees and credit any overpayment of fees for the petition or for entry of this amendment to Attorney's Deposit Account No. 50-2041 (Whitham, Curtis & Christofferson P.C.).

Respectfully submitted,

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